Batteries, Lead/Acid

Revised 2018

Introduction

Batteries held at ambient temperatures, without refrigeration, lose moisture in storage which must be replenished. There is no loss under refrigerated storage. Commercial experience indicates recharging every 3 months is necessary with storage temperatures from ambient to 90°F (32°C). Refrigerated storage makes this unnecessary within desired practical time limits of storing. True dry-charged batteries show no self-discharge at temperatures up to 90°F (32°C). Wet charged batteries maintained with proper charging frequency and stored at 80°F (27°C) or below should be placed in service within a year after manufacture. Continuous storage at lower temperatures would moderately extend this maximum storage life. However, maintenance of battery quality extends beyond the mere requirement to maintain specific gravity. Grid corrosion and active material integrity are both vital time and temperature dependent parameters that drastically affect battery performance and life. In addition, the extreme variations of battery design make it virtually impossible to arrive at a simple storage life-battery temperature relationship.

Refrigerated storage rooms should provide for adequate air exchange and circulation to avoid the accumulation of highly explosive hydrogen gas.

Battery Types

A. Battery Type by Construction or Application

1. **Wet Charged**. Wet charged batteries are the most common type of battery. These batteries are fully charged with an observable reservoir of acid about the plates. Wet charged automotive starting batteries manufactured in the U.S. have grid antimony contents of 0-3%.
2. **Moist Charged**. A moist charged battery is essentially a wet charged battery that has been dumped of acid and has had the vents sealed or semi-sealed for the purpose of storage. Because of the low acid to paste ratio of these batteries, they should be placed in service within a year no matter how optimum were the storage conditions. The specific gravity loss as a function of storage time of the residual acid in this type of battery is considerably greater than a wet charged battery. Because of this, moist charged batteries should not be stored below 32°F (0°C). Moist charged batteries normally have a positive grid alloy content in the 1.5-3.0% range. Moist charged batteries are often inadvertently misrepresented as "dry charged" batteries.

3. **Dry Charged**. In dry charge batteries, the plates have been formed, washed, and dried prior to battery construction. No acid remains inside of a dry charged battery. This type of battery is the most stable during storage. The military stores them in war storage for a minimum of 5 years.
4. **Deep Cycle**. Deep cycle batteries are specially constructed designs that permit consecutive deep cycling with minimum damage to the battery. These batteries normally use higher levels of antimony in both the positive and negative grids (3-6%) to permit continuous deep cycling. However, there are some special application antimony-free, immobilized electrolyte deep cycle batteries currently available in the U.S. market. However, the greater antimony levels of most deep cycle batteries cause them to self-discharge at a faster rate than starting batteries. Examples of batteries that fall into this category would be marine deep cycle and golf cart batteries.
5. **Immobilized Electrolyte/Recombination/Absorptive Glass Mat (AGM) Batteries or Gelled Batteries**. This type of battery uses either absorptive separators between the plates which hold up to 95% of their volume in acid or the electrolyte is "gelled." Gases generated by the battery during charging are consumed by the battery's active material. This allows the battery to be completely sealed. Batteries of this type are very sensitive to proper charging and storage conditions. For this reason, antimony-free grids are usually used. Batteries of this type have the advantage of the absence of acid spills. However, if improperly recharged or operated in a high temperature, they may experience abbreviated life.

B. Battery Types Characterized by Electrolysis Rate of Acid

1. **Maintenance Free.** A maintenance-free battery contains non-antimonial positive and negative grids, or may contain positive grids with antimonial content less than 2%. Separators could be either of the leaf or envelope variety. The low antimony content of these batteries provides a low electrolysis rate of the electrolyte at the applied potentials and temperatures seen in starting service. It is normally implied that water need not be added during the life of a maintenance-free battery. The electrolyte may or may not be accessible.
2. **Hybrid**. A hybrid battery implies a specific arrangement of grid alloy composition. The positive grid is normally 1-3% antimonial alloy for cycling and charging. The negative grid is normally a non-antimonial alloy for low electrolyte electrolysis. If the positive grid antimony content is less than 2%, the battery is normally considered maintenance free. If the positive grid contains between 2-3% antimony, the battery is normally considered low maintenance, a term coined to indicate a battery is not quite up to the low electrolysis capability of a maintenance-free battery.
3. **Standard**. A standard battery normally uses antimony contents of about 3% or higher in both positive and negative grids. If the antimony content of both grids is dropped below 2%, this type battery might be termed low maintenance. This standard battery type has been reduced to a minority status in the U.S.

Self-Discharge of Wet Batteries

All automotive wet batteries will slowly discharge on standing and will discharge much faster when warm than when cold. They may discharge faster when fully charged than when only partially charged. At normal temperatures of 80°F (26.7°C) losses averaging between 0.0014 and 0.0020 volts per day are typical. The effect of temperature on self-discharge for the average fully charged new battery in good condition may be about as follows:

Maximum Discharge Rate for Hybrid and Calcium Batteries	
At 100°F (37.8°C)	0.0025 Sp. Gr. per day
At 80°F (26.7°C)	0.0010 Sp. Gr. per day
At 50°F (10°C)	0.0003 Sp. Gr. per day

The above values are approximate for about the first 10 days of standing after being fully charged. Some makes of batteries will have a higher and some a lower rate of self-discharge than the above, depending upon the methods of manufacture and the purity of materials used. To minimize the extent of self-discharge, store batteries in as cool a place as possible, away from hot air ducts or radiators in winter and shielded from direct sunlight in summer.

The usual period of storage for automotive batteries starts in February, March, and April which are historically the slow months for marketing. Battery stock would start decreasing in August through October as seasonal demand increases. From the above, it can be seen that much is gained by storing wet charged batteries in a refrigerated warehouse during the summer months. Practically no loss would take place in most new unused batteries kept at 20°F (-7°C) over a 6 or 7 month period of time.

Storage Temperatures and Recharging Requirements

The extreme variations of battery design make it difficult to arrive at a simple battery temperature relationship.

Storage Temperature		Months Until Recharging Required
°F	°C	
30	-1	16
50	10	12
70	27	9
80	27	6
90	32	4
100	39	2.5
110	43	1.5

120	49	1

Tolerance for Temperature Changes

Hard-rubber cased and plastic cased batteries are not adversely affected by refrigerated storage. Experiments of a battery manufacturer indicate that batteries can be cooled to -65°F (-54°C) without freezing or damage providing they are fully charged. The hard rubber or plastic cases become more brittle and are more easily broken at low temperatures so use greater care in handling. Moist charged batteries should not be stored at less than 32°F (0°C) due to the possibility of a low specific gravity residual acid in the battery.

Avoid storing in rooms where relative humidity (RH) is high. Absorption of moisture in the paperboard may cause softening, crushing and distortion. Storage experience suggests that maintenance of an RH of 60-70% during storage will keep the cartons dry enough. At 80-85% RH, they may soften and become easily crushed.

It is likely also that with a relatively dry dust cover due to proper humidity in storage the effect of a slight amount of condensation due to dew-point effects on the cover, when the batteries are removed from storage at 28 to 32°F (-2 to 0°C), will not be significant.

Batteries stored at 32°F (0°C) are affected very little by condensation, either on the case or carton, when removed from cold storage except in very humid and/or warm weather. Batteries held at 0°F (-18°C) or lower do show considerable condensation on the case and carton, but no significant damage is likely to occur.

Inspection at Receiving

It is recommended that each battery be inspected at receiving for cracks, breakage, leakage, or spillage. Damage should be noted and reported and damaged batteries set aside for disposal as instructed by owner. It is important to note evidence of damage before the batteries are stored since leakage will soften and stain dust covers and create a disagreeable problem of clean up. Clothing, floors and equipment are also damaged by the sulfuric acid electrolyte.

Spillage or Leakage of Battery Electrolyte

Battery electrolyte is very acid and corrosive. Warehouse personnel should be properly cautioned. If the battery solution gets on the hands or skin, it should be removed at once by washing with plenty of fresh, clean water. Acid splashed in the eyes should be removed in the same manner. A doctor should be consulted to be certain that possible dangerous injury is properly cared for. Use of a plastic face shield to avoid splashing eyes and face is recommended.

Soda ash should be on hand to neutralize acid spillage, as well as clean rags or waste for mopping up small amounts of acid. If battery electrolyte is spilled on a battery, it should be removed at once. For this purpose, use clean rags with a water solution of soda ash at the mixture concentration of 0.5 lb of soda ash to 1 gal of water, followed by washing with fresh clean water. Soda ash is caustic especially when wet. Precautions must be taken to prevent soda ash from contacting eyes or skin or from being inhaled.

Stacking and Palletizing

Batteries palletize readily due to their regular cubical dimensions. Batteries are palletized during manufacture, but the customary pallet dimensions seem to differ from those usually used in refrigerated warehouses.

Batteries are usually shipped in trucks in 1 to 3 layers on the bed of the truck body. In any type of warehousing they should be on shelves if stacked more than 2 layers high for long periods of time. Batteries should not be stacked on pallets higher than received from the manufacturer or distributor.

Great care must be taken to prevent batteries from being shorted out or shorted together. If the posts of a battery are inadvertently bridged by a conductor such as a wrench, pipe or metal rack, the posts can melt and splatter molten metal that is capable of causing burns or igniting fires. Wet cardboard can also act as a conductor capable of discharging batteries.

Cartons or Dust Covers

When delivered to a warehouse, batteries will probably have bottomless cardboard dust covers which are not moisture-vapor-proof. These covers merely protect the batteries from external marring or discoloration. Warehouse personnel should be cautioned not to try to lift batteries by the sides of their dust covers because they have no bottoms. Take hold underneath of the battery and dust cover as a unit. While these dust covers have cardboard rims or folded and perforated supports underneath their tops to support them on the battery case, they are not designed to support heavy weights. However, these covers have been observed standing up without crushing in a 4-high stack of batteries where only heavy cardboard sheets (and with no vertical board supports) was used.

It is important that batteries never be stored on their sides or stood on end.

If the battery electrolyte level seems to be lower than normal in cold batteries, in storage or just removed from storage, let the batteries come up to atmospheric temperature before rechecking the solution level or adding water.

Racks for Storage

Simple racks for temporary battery storage can be made from loose flat boards supported by the batteries themselves. No nails are required. All boards are cut from 3/4" stock. Uprights may be 10" high, with the grain, and about 12" wide. Shelf boards can be 4" wide and 38" long, the lumber to be free from unsound knots. Eight uprights and 10 shelf boards will permit stacking 25 batteries, 5 batteries per row and 5 tiers high, if desired. The stack is built up as follows:

Lay parallel on a smooth flat floor two shelf boards spaced so that the bottom ends of the batteries are supported by them. Place 5 batteries side by side in a row and insert one upright between batteries - nos. 1 and 2 and one between Nos. 4 and 5, pushing the batteries up snugly together so as to support the upright pieces. When not in use, the rack boards can be compactly stored. The above rack is only for compact, temporary storage.

Automobile Battery Density

Automobile batteries usually average between 40 and 50 pounds each, although the full range of weight extends from 28 to 57 pounds depending on the types of batteries. Batteries are often estimated to be about 93 pounds per square foot. Larger size truck and bus batteries may weigh over 100 pounds each and be 100 or more pounds per square foot.

On a 36 x 48 pallet, it is possible to stack 18 batteries of the Group 24 type which is the most popular size. About 85% of the industry's output of from 35 to 40 million batteries each year is 12-Volt sizes and this percentage is increasing yearly.

Recharging Batteries

The following guidelines must be adhered to when recharging lead acid storage batteries:

1. Batteries should not be recharged until their voltage drops below 12.4 volts.
2. All batteries must be recharged at temperatures (batteries and ambient) between 70 to 90°F (21 to 32°C).
3. Proper ventilation must be provided in areas where batteries are being recharged due to hydrogen evolved during charging.
4. No sparks, open flames or smoking can be in the area where batteries are being recharged.
5. All personnel involved in recharging batteries should wear a face shield, rubber gloves and a protective apron.
6. Follow all guidelines and instructions provided by the charger manufacturer. Pay particular attention to matching the battery voltage (6 or 12) to the proper charger setting.
7. Follow specific charging instructions indicated on the battery.
8. Only wet charged batteries should be recharged prior to being placed into service.

9. Moist charged and dry charged batteries should not be recharged until placed into service.

Recharging of immobilized, recombination or absorptive glass mat type batteries must follow the manufacturer's recommended procedures. No general charging instructions for these types of batteries will provide adequate recharging without danger of damaging overcharge.

There are three basic types of battery chargers available and therefore three different basic guidelines for recharging batteries. With any of these charging schemes, if the battery becomes hot to the touch or starts to produce a rotten odor, discontinue charging immediately.

1. **Tapered Charges** - Usually has a few operator adjustments, a switch for 12 or 6-volt batteries and possibly a switch to set the maximum charging current. To recharge batteries whose voltage has dropped to 12.40 volts or lower, set this type charger to the proper battery voltage, to a current of no more than 10 amps and charge the battery for approximately 8 hours.
2. **Fixed Voltage Charger** - Has adjustments for current and voltage. To recharge batteries whose voltage has dropped to 12.40 volts or lower, set this type charger to 15.5 volts with a maximum of 20 amps and charge the batteries for approximately 8 hours.
3. **Constant Current Chargers** - Has adjustments for current only. To recharge batteries whose voltage has dropped to 12.40 volts or lower, set this type charger to 5 amps/charge for approximately 8 hours.

Storage Compatibility

It is advisable not to store wet charged batteries with food products or any items that would react quickly with acids, particularly sulfuric acid, that could escape from the batteries. Acids could react rapidly with most caustic and/or chemical base compounds. Caution must also be used in storing wet charged batteries with materials that could be damaged in the event of an acid spill if the battery containers are inadvertently broken, or overturned. Sulfuric acid can react with many metals, including galvanized steel and aluminum, rapidly producing large volumes of explosive hydrogen gas. Such a reaction may cause the acid to splatter and strong fumes to be generated.

Safety Precautions

Batteries contain sulfuric acid and produce explosive mixtures of hydrogen and oxygen. Because self-discharge action generates hydrogen gas, even when the battery is not in operation, make sure batteries are stored and worked on in a well-ventilated area. ALWAYS wear ANSI Z87.1 (U.S. standard) approved safety glasses and face shield or splash proof goggles when working on or near batteries.

- Always wear proper eye, face and hand protection.
- Keep all sparks, flames and cigarettes away from the battery.
- Never try to open a battery with non-removable vents.

- Keep removable vents tight and level except when servicing electrolyte.
- Make sure work area is well ventilated.
- Never lean over battery while boosting, testing or charging.
- Exercise caution when working with metallic tools or conductors to prevent short circuits and sparks.

Safe Charging

Never attempt to charge a battery without first reviewing the instructions for the charger being used. In addition to the charger manufacturer's instructions, these general precautions should be followed:

- Always wear proper eye, face and hand protection.
- Always charge batteries in a well-ventilated area.
- Keep vents tight and level.
- Turn the charger and timer "OFF" before connecting the leads to the battery to avoid dangerous sparks.
- Never try to charge a visibly damaged or frozen battery.
- Connect the charger leads to the battery; red positive (+) lead to the positive (+) terminal and black negative (-) lead to the negative (-) terminal. If the battery is still in the vehicle, connect the negative lead to the engine block to serve as a ground. Be sure the ignition and all electrical accessories are turned off. (If the vehicle has a positive ground, connect the positive lead to the engine block.)
- Make sure that the charger leads to the battery are not broken, frayed or loose.
- Set the timer, turn the charger on and slowly increase the charging rate until the desired ampere value is reached.
- If the battery becomes hot, or if violent gassing or spewing of electrolyte occurs, reduce the charging rate or turn off the charger temporarily.
- Always turn the charger "OFF" before removing charger leads from the battery to avoid dangerous sparks.

Handling Battery Acid

Battery acid, or electrolyte, is a solution of sulfuric acid and water that can destroy clothing and burn the skin. Use extreme caution when handling electrolyte and keep an acid neutralizing solution, such as baking soda or household ammonia mixer with water, readily available. When handling batteries:

- Always wear proper eye, face and hand protection.
- If the electrolyte is splashed into an eye, immediately force the eye open and flood it with clean, cool water for at least 15 minutes. Get prompt medical attention.

- If electrolyte is taken internally, drink large quantities of water or milk. DO NOT induce vomiting. Get prompt medical attention.
- Neutralize with baking soda any electrolyte that spills on a vehicle or in the work area. After neutralizing, rinse contaminated area clean with water.

To prepare electrolyte of a specific gravity, always pour the concentrated acid slowly into the water. DO NOT pour water into the acid. Always stir the water while adding small amounts of acid. If noticeable heat develops, allow the solution to cool before continuing to add acid.

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